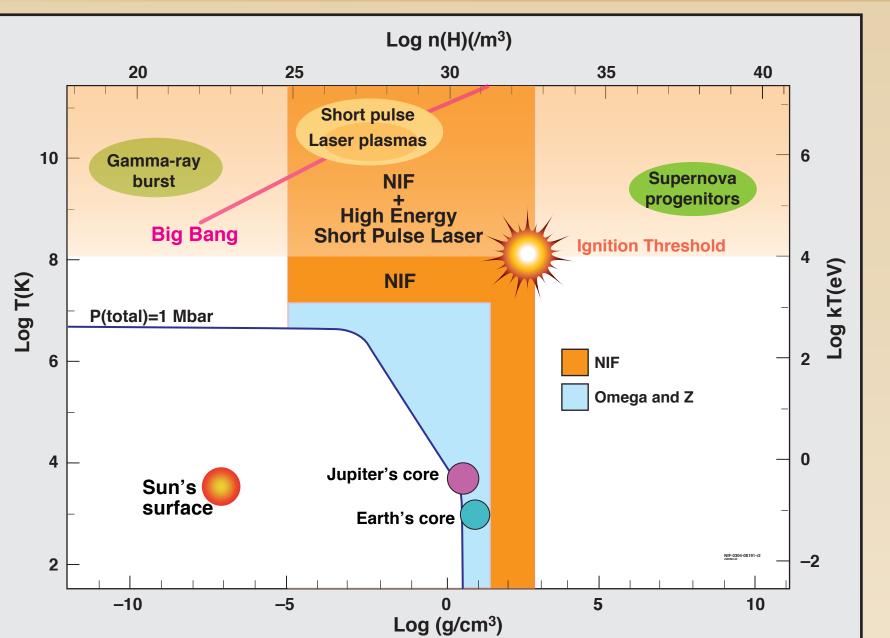
Indirect and Direct Drive Implosion Platforms on the National Ignition Facility

Why Implosions?

Implosions on the NIF enable us to access unprecedented HED experimental regimes



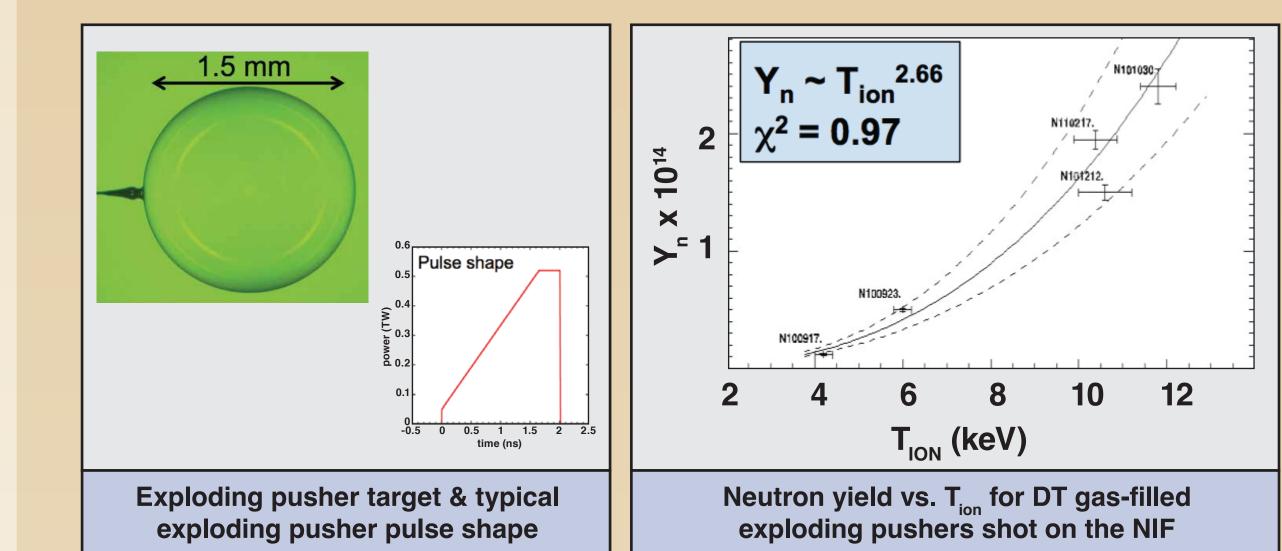
- Physical processes at a range of temperatures and pressures approaching 10⁸ K and 10¹¹ bar in a
- laboratory-controlled setting Generate thermonuclear ignition and energy gain
- Astrophysically relevant conditions such as those that exist in the sun, giant planets such as Jupiter, and brown dwarfs
- Highly ionized, near-solid-density mid-Z and high-Z plasmas at keV temperatures to benchmark atomic
- High nuclear reaction yields allow for the study of nucleosynthesis processes

Direct Drive Platforms

These platforms are driven by the NIF beams directly incident on the capsule

Exploding pushers

 Targets typically thin-walled glass spheres ~1.5 – 2.1 mm in diameter, filled with DT or DD gas at room temperature Main function is to provide sources of 14-MeV neutrons for diagnostics commissioning



- **Current conditions achieved**
- High $Y_n \sim 10^{13}-10^{14}$
- High-temperature ~ 10 keV

Current conditions achieved

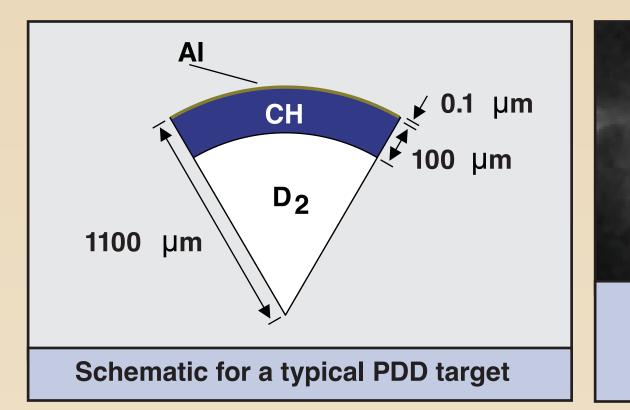
Hot spot temp ~ 2 keV

pR ~ 400 g/cm²

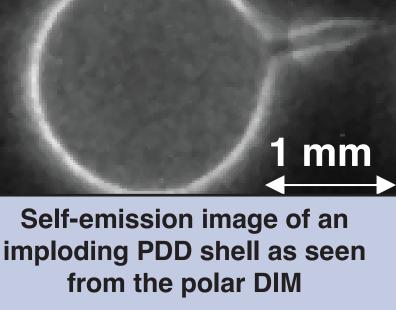
Low density ~ 5 g/cm³

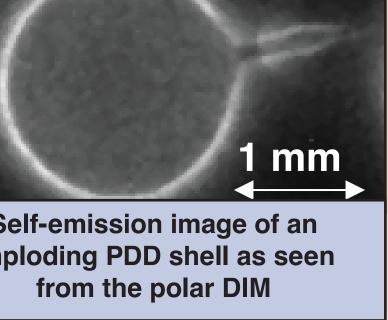
Polar Direct Drive (PDD) / Defect-Induced Mix Experiments (DIME)

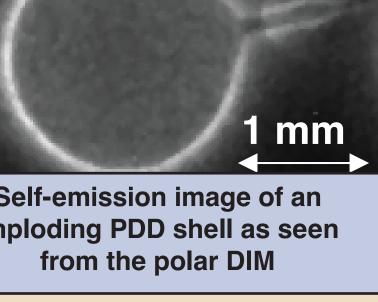
- The current PDD experiments focus on shell symmetry and LPI in direct-drive implosion on the NIF, with the goal
- of developing a direct-drive ignition platform
- · Targets typically plastic shells, 2.2 mm in diameter, filled with DD gas, and fielded at room temperature

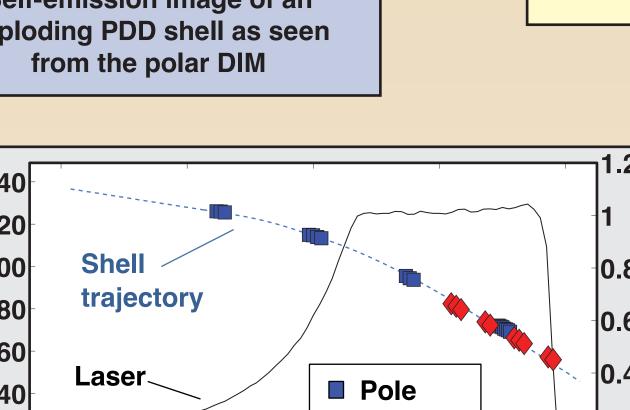


NIF beams are repointed towards the









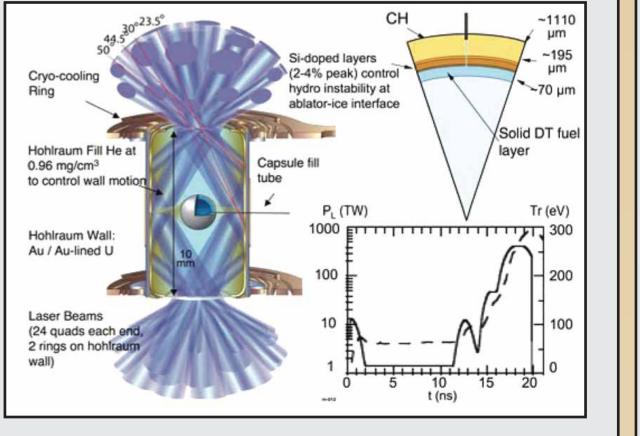
The shell trajectory is recorded with x-ray framing cameras over the full laser drive

Indirect Drive Platforms

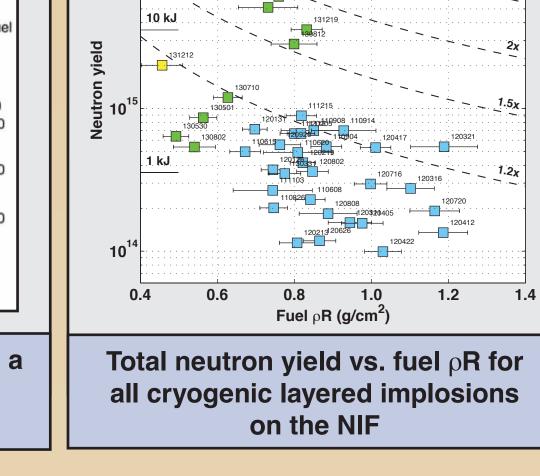
These platforms are x-ray driven using hohlraums

Layered DT ignition capsules

- Contain solid cryogenic DT fuel layers
- Designed to ignite and burn producing ~10-20 MJ of energy



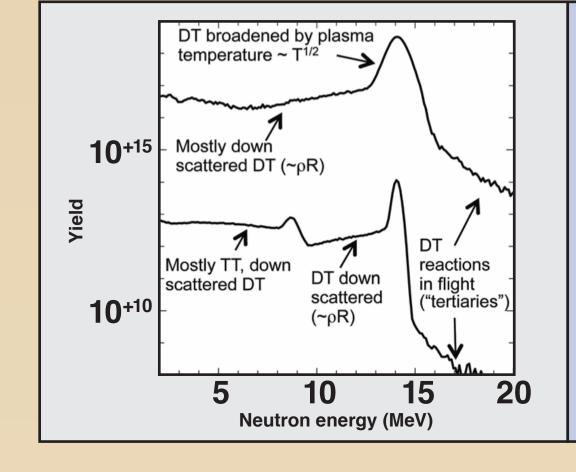
simulated X-ray drive (dashed line)

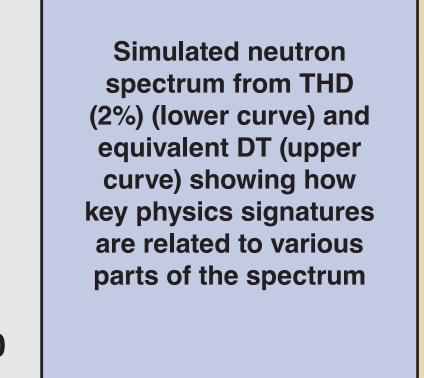


Current conditions achieved High $Y_n \sim 10^{14}-10^{16}$ Rapid burn ~ 50-100 ps Burn avg temp ~ 5 keV Burn avg density ~150-300 g/cm³

THD capsules

- Contain solid cryogenic fuel layers that are hydrodynamically equivalent to DT layers
- Fuel composition of tritium(2-6%)-hydrogen-deuterium lowers the yield to enable detailed diagnosis of the implosion





Current conditions achieved • Y_n ~ 10¹⁴ Hot spot temp ~ 4 keV Main fuel density ~ 500 g/cm³ surrounding a lower-density ~ 50 g/cm³

 $Y_{n} \sim 10^{12} (DD)$

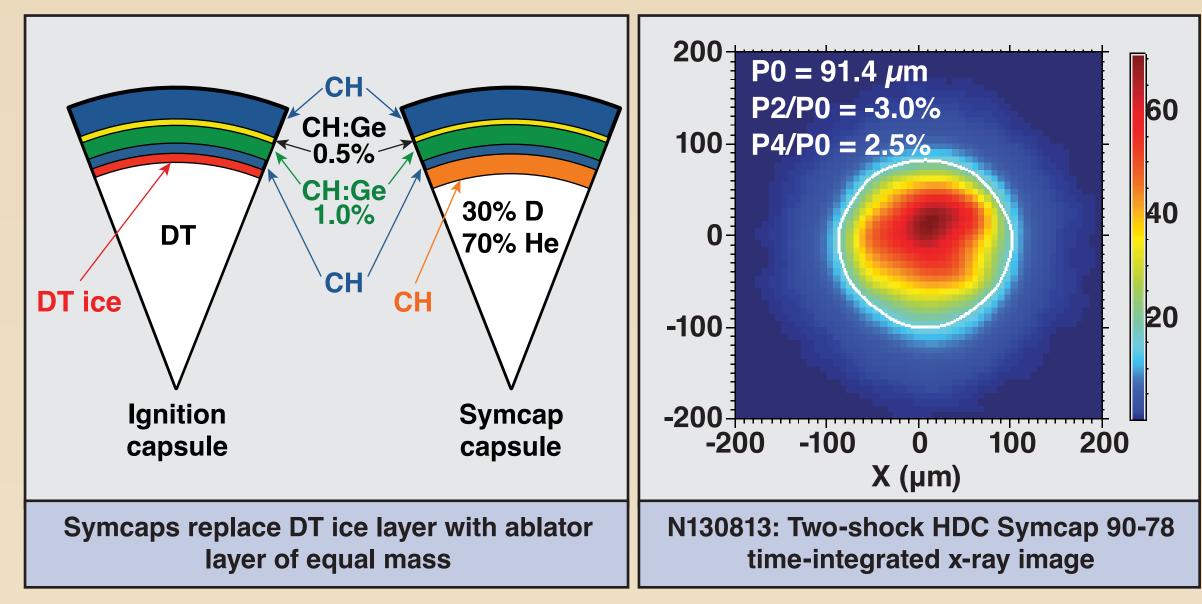
Hot spot density

~ 20-50 g/cm³

Hot spot temp ~ 1-4 keV

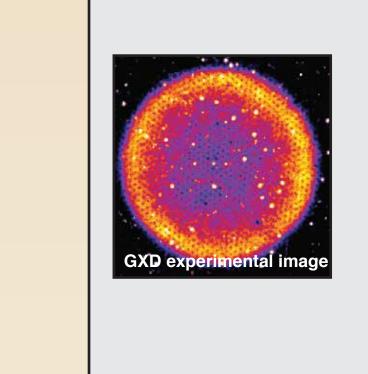
Symmetry capsules or "Symcaps"

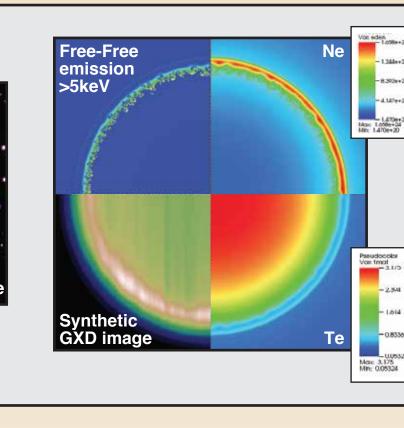
- · Identical to ignition capsules except they do not contain a fuel layer but rather a gas mixture and serve as a surrogate to study, tune, and optimize implosion symmetry
- Can be fielded over a range of temperatures from cryogenic to room temperature
- Range of hydrogen-helium gases can be accommodated



Indirect-Drive exploding pushers

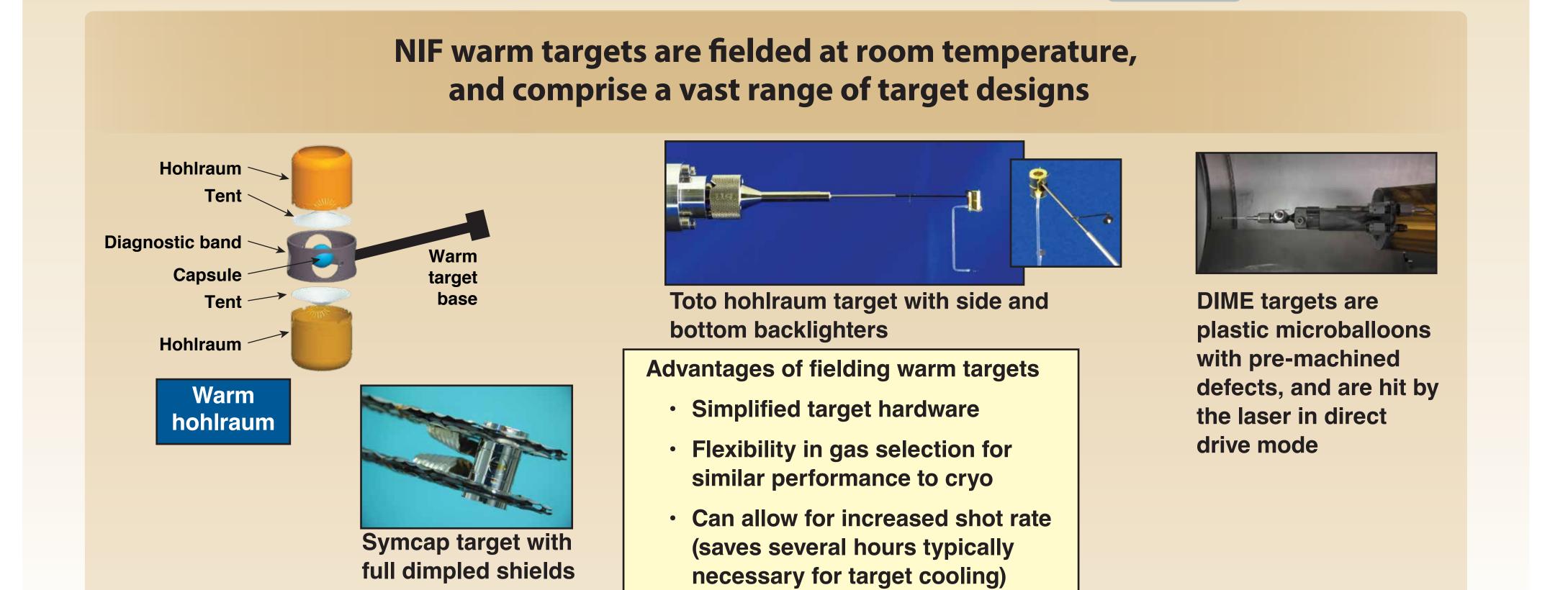
- Thin shell spherical capsule filled with DD or DT gas
- Low convergence spherical implosion in near-vacuum hohlraum
- Exhibits near ideal 1-D behavior, >98% laser-to-hohlraum coupling





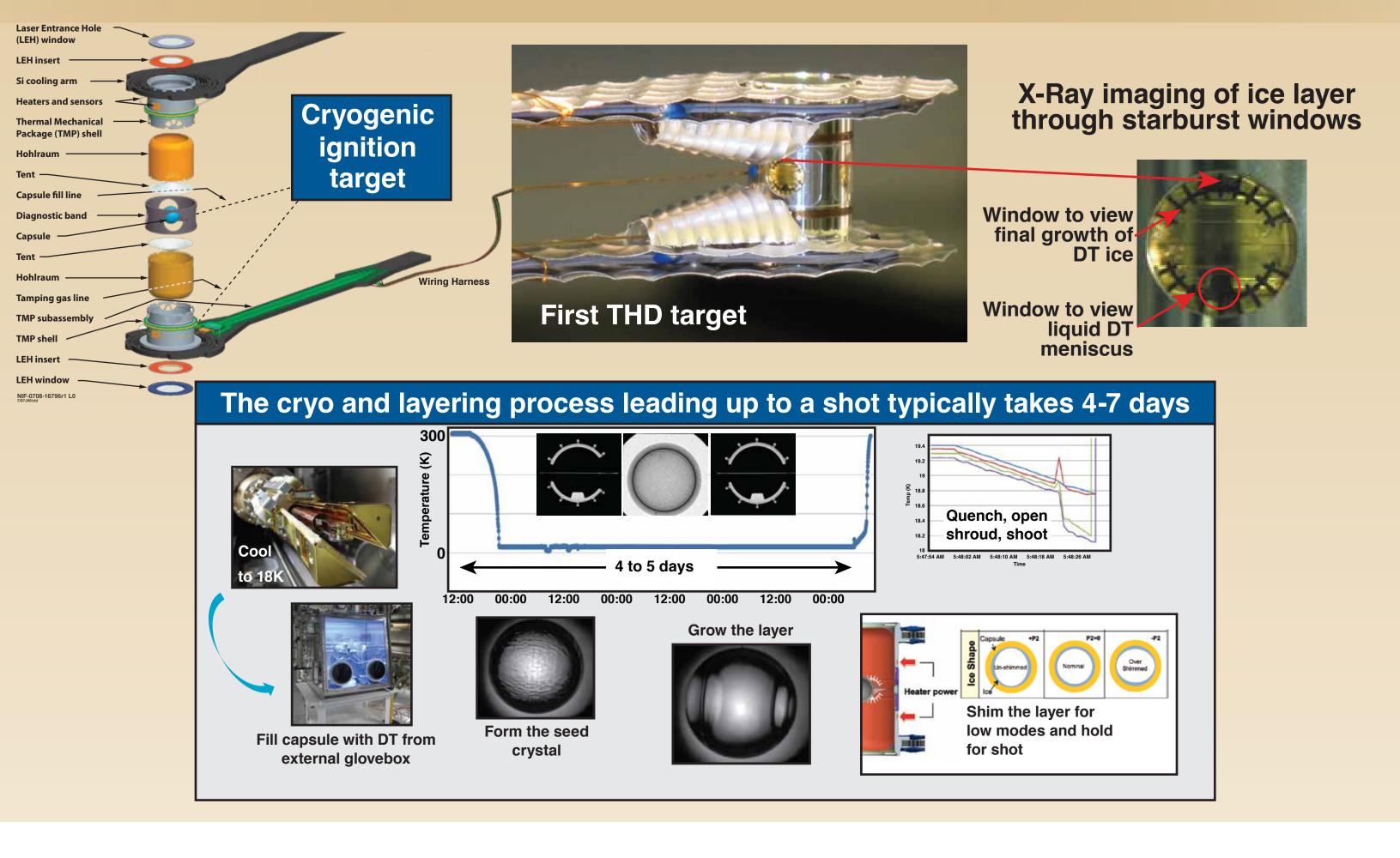
Current conditions achieved $Y_n \sim 10^{12} (DD), 10^{14} (DT)$ Hot spot temp ~ 2-5 keV Hot spot density ~ 0.5-2 g/cm³

Warm Targets



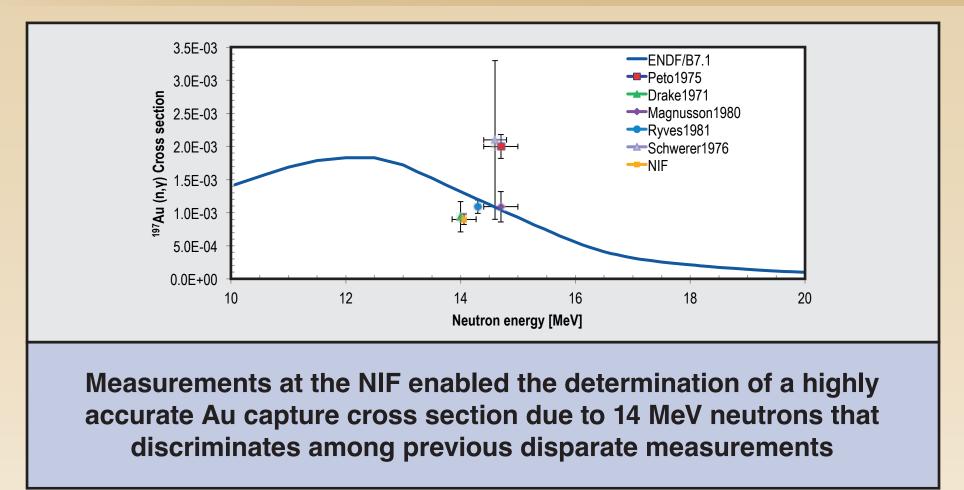
Cryogenic Targets

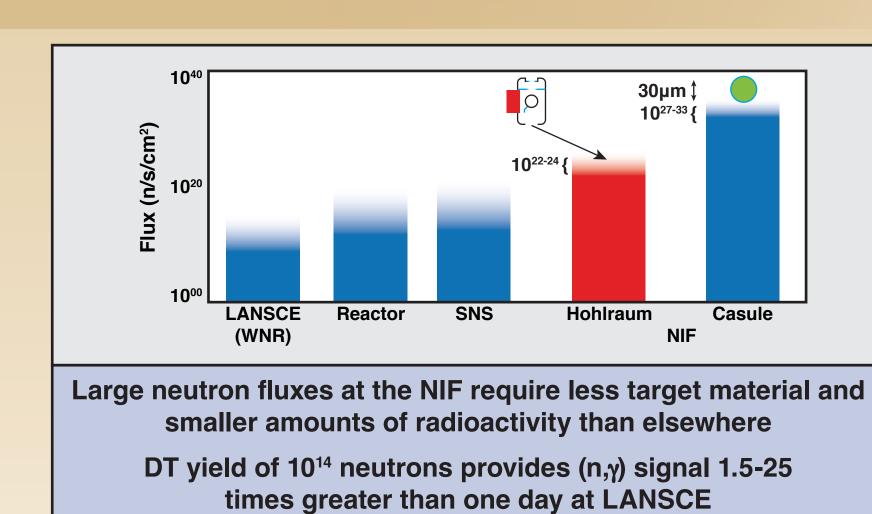
NIF cryo targets use a standard platform, adding features as needed for the specific experiment



Nuclear Physics at the NIF

The NIF provides a unique capability for nuclear science





Diagnostic Configuration

There are a large number of diagnostics to measure neutron, x-ray, and γ-ray emission from these implosions

Diagnostic Name	Acronym	Purpose
Nuclear Diagnostics		
Neutron Time of Flight	NTOF	Neutron time of flight measurement
Gamma Ray History	GRH	Temporally and spectrally resolved gamma emission
Radiation Chemistry	Rad Chem	Neutron activation, charged particle activation, gaseous and solid collection
Magnetic Recoil Spectrometer	MRS	Neutron spectrum - neutrons converted to protons, energy analyzed by magnetic deflection
Neutron Wedge Range Filter Spectrometer	WRF	Energy resolved particle emission - neutron yield and spectral shape
Neutron Imager System	NIS	Image primary and downscattered neutrons
Neutron Activation Detector	NAD	Absolute broadband neutron spectrometer by activation of witness foils
Particle Time of Flight Detector	pTOF	Neutron bang time and temporally and spectrally resolved proton measurement from D ³ He reactions
X-Ray Diagnostics		
Gated X-Ray Detector/Imager	GXD, hGXI, hGXD	Temporally and spatially resolved high-energy (hardened) x-ray imaging
Static X-Ray Imager	SXI	Pinhole imaging at 900 eV or 3-6 keV
Dante	Dante	Temporally and spectrally resolved soft x-ray power
Filter Fluorescer X-ray diagnostic	FFLEX	Absolute hard x-ray emission 20-500 keV
Equatorial X-Ray Imager	EHXI	Static pinhole imaging of >40 keV
South Pole Bang Time	SPBT	Time of peak x-ray emission, absolute x-ray emission at 11 keV
Streaked Polar Spectrometer	SPIDER	X-ray burn history
Optical Diagnostics		
Full Aperture Backscatter Station/ Near Backscatter Imager	FABS/NBI	Measurement of scattered light

13-17 MeV

 $P0 = 34 \pm 4 \text{ um}$

 $P2/P0 = -34 \pm 5 \%$

-100 -50 0 50 100 x, um

6-12 MeV

 $P0 = 50 \pm 4 \text{ um}$

 $P2/P0 = 0 \pm 5 \%$

Neutron Imaging provides images o

the dense core where DT fusion

occurs, and images of the region

where neutrons scatter from the

 $h_V > 6 \text{ keV}$

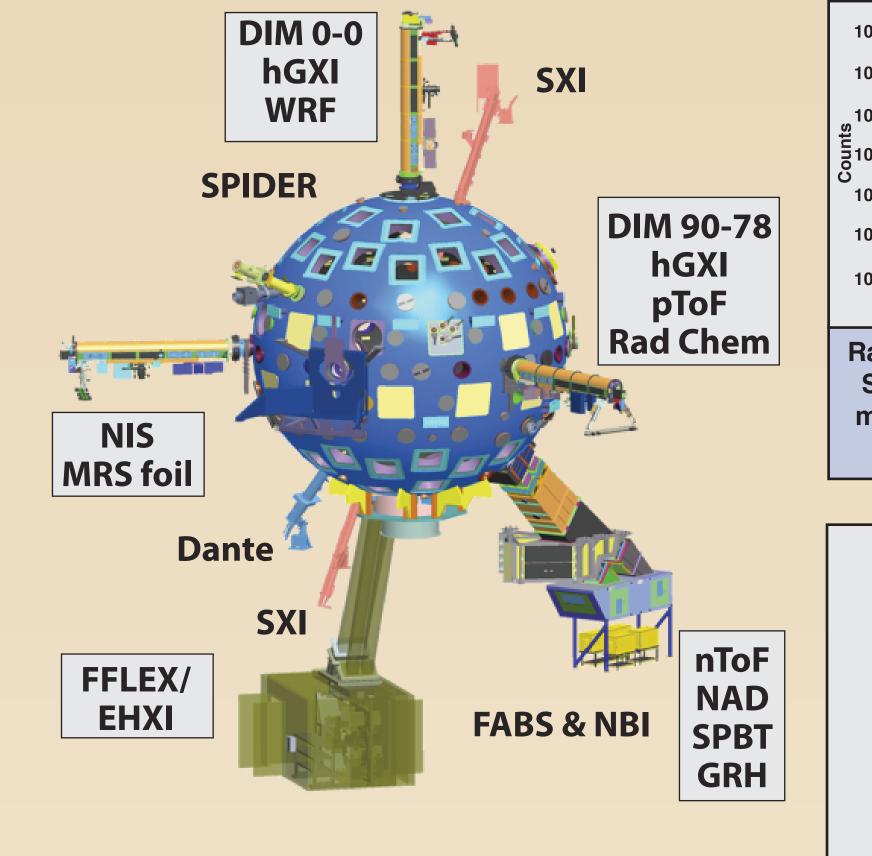
surrounding dense fuel

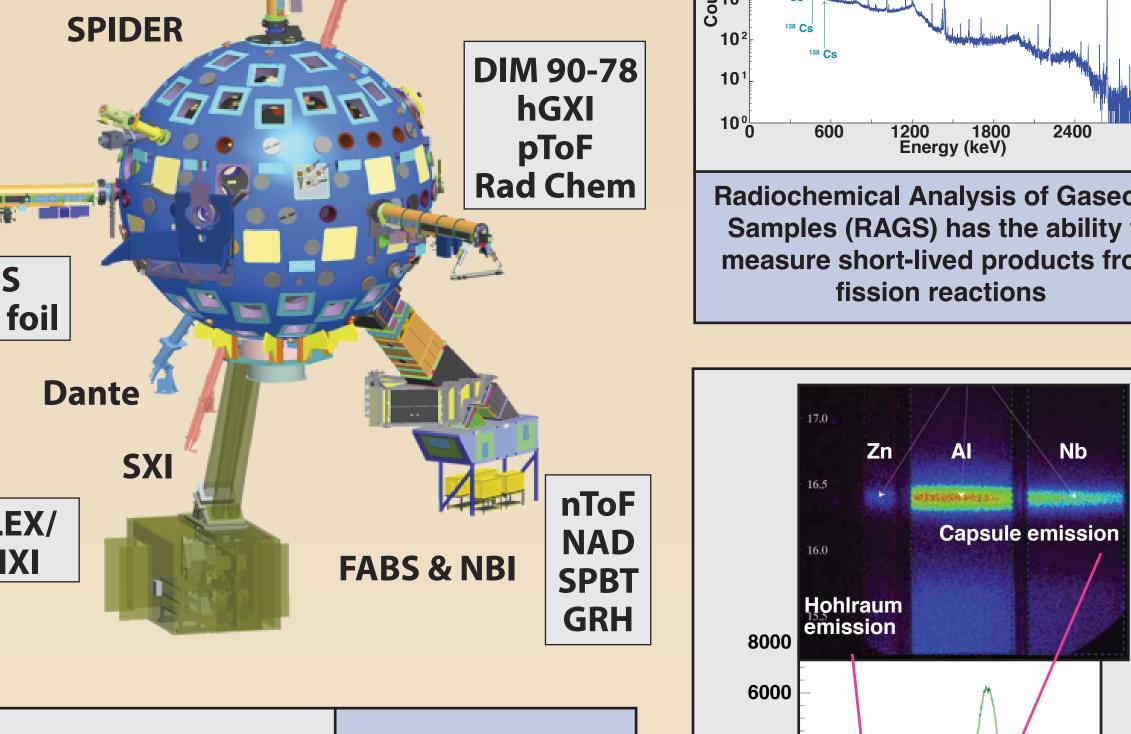
N131119

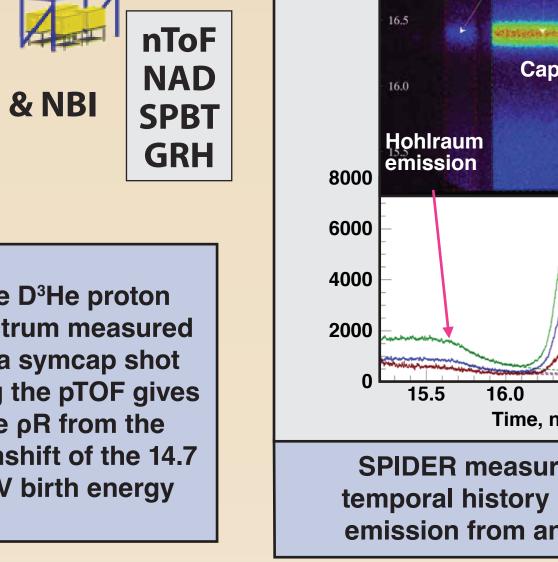
-100 -50 0 50 100 X (um)

X-ray self-emission imaging provides a snapshot of the imploded core

P4/P0 = 1 %







The D³He proton spectrum measured

SPIDER measures the full temporal history of the x-ray emission from an implosio

For more information visit lasers.llnl.gov/news/publications



P417755_Platforms_Ma